Patent Office," which costs sixpence. The list consists of two parts; first, a general alphabet of subject headings, with entries in chronological order of the works arranged under these headings, and, secondly, a key, or a summary of these headings shown in class order. The list comprises 2374 works, representing 3792 volumes.

THE series of eight lectures on "Physical Chemistry and its Applications," delivered some time ago by Prof. J. H. van 't Hoff at the invitation of the University of Chicago, has recently been translated into French by Prof. Corvisy (A. Hermann, Paris). No higher tribute to the intrinsic merit of these most readable lectures could be desired, and they will no doubt be warmly received by a large circle of French readers.

SOME noteworthy experimental results communicated by Messrs. van Calcar and Lobry de Bruyn to the current volume of the *Recueil des Travaux chimiques des Pays-Bas,* vol. xxiii. p. 218, show that considerable changes take place in the concentration of solutions under the influence of centrifugal forces. The concentration increases from the axis of rotation towards the periphery, and the changes have been accurately measured in the case of potassium iodide and cane sugar. Portions of a solution of potassium iodide of 0·2035 normal concentration, removed respectively from points near the axis of rotation and some distance away, were found to be 0·1065 normal and 0·325 normal. These portions of solution were removed after centrifuging for three hours at the rate of 2400 revolutions per minute. A saturated solution of Glauber's salt, containing 8·8 per cent. Na_2SO_4, deposited 57 grams of solid $Na_2SO_4.10H_2O$ at the periphery after being rotated for five hours, and the remaining solution was found to contain only 5·5 per cent. of sodium sulphate. It is calculated that the applied force acting on the molecules at the periphery (radius of rotation=6 cm.) in these experiments was more than 400 times greater than gravitational force.

IN the *Revue de Metallurgie* for April, M. H. Le Chatelier re-states and explains his views on the constitution of the carbon-iron alloys. He points out the importance of classifying the constituents of heterogeneous bodies, and again directs attention to the similarity between alloys and igneous rocks. In chemical classification it is necessary to give the chief place to the conception of phases, and to regard chemical composition as of secondary importance. If chemical composition alone were used for purposes of classification, there would be no distinction, for example, between crystallised granite and fused granite, although the former contains three phases, quartz, felspar and mica, and the latter contains only one phase. Moreover, it is desirable to give names to the phases, even when they are solid solutions of variable composition. One of the great difficulties in determining the phases in the steels is that the individual crystals are generally so minute that they cannot be isolated, and their properties and chemical composition cannot be exactly determined. Nevertheless, some progress has been made in the recognition of the various phases that may occur. M. Le Chatelier believes that these phases include iron in its various allotropic forms; carbon in the form of graphite; cementite, or Fe_3C; and many solid solutions containing iron and either carbon, nickel, manganese, phosphorus, silicon, or other elements. Most of these phases have not yet received names, but the highly important carbon-iron solutions have been called troostite, martensite, and austenite. The homogeneity of these phases has been called in question, but the attempts to prove that they are heterogeneous have not yet been successful. Difficulties are occasioned by the similarity of the properties of these three solutions, and the evidence that they are distinct rests mainly on their appearance under the microscrope after treatment by different reagents. It is scarcely necessary to add that these views are not shared by some students of metallography

OUR ASTRONOMICAL COLUMN.

THE GOVERNMENT OBSERVATORY, BOMBAY.—The report of the Bombay Observatory for the year ending December 31, 1903, signed by the director, Mr. N. A. F. Moos, gives an account of the many and varied observations carried out there. The instrumental equipment is extensive and in good order, the records of failure by the automatic registering instruments being very few.

The rainfall for the year was 84·49 inches, a surplus of 9·33 inches above the average of the twenty-four years 1873–1896. The daily wind pressures and temperatures were recorded regularly, and many magnetic and seismographic observations were made daily. Routine observations with the transit instrument, to check the standard clocks, were made at regular intervals, and a very good time service was maintained at the docks and other public places. The rating and adjustment of chronometers and deck-watches for Government departments and ships, and for private ship owners, formed an important part of the year's work.

NEBULOUS AREAS OF THE SKY.—In an article published in *Popular Astronomy* (No. 6, vol. xii.), Prof. H. C. Wilson, of the Goodsell Observatory, discusses the subjective existence of the large nebulous areas of the sky as described by Sir William Herschel. He fully confirms Herschel's observations, and considers that the negative results obtained by Dr. Roberts last year must have been due to unfavourable observing conditions. Further, he shows by a reproduction of one of his own beautiful photographs of the Pleiades region, which was taken with a 6-inch Brashear star-camera, that at least one of the regions described by Dr. Roberts as containing no nebulosity is in reality filled with nebulous matter, covering as many square degrees as Herschel allotted to the whole of the nebulosities in his fifty-two regions.

Profs. Wilson and Payne intend transporting their photographic equipment to a station situated in the western Montana mountains at an altitude of about one mile, so that during July and August they may test the suitability of the atmosphere at that altitude for photographing the nebulous patches of the Milky Way, and, if possible, obtain further confirmatory photographs of Herschel's regions.

LIGHT CURVE OF δ CEPHEI.—From an exhaustive discussion of the available data concerning the magnitude variations of δ Cephei, M. Beliawsky, of St. Petersburg, has derived the following elements:—

Minimum 0=1840 September 24·833d. M.T. Bonn.
Period=5·36642 days.

The period between a maximum and the succeeding minimum, according to the curve, is 1d. 11·184h., and this value is very near the mean of the values obtained by five previous workers. The light of the star varies between magnitudes 4·37 and 3·57, and M. Beliawsky gives the estimated magnitude for every 0·1 day between two succeeding minima (*Astronomische Nachrichten,* No. 3952).

POSITION OF THE AXIS OF ROTATION OF MARS.—*Bulletin* No. 9 of the Lowell Observatory gives the results of a new determination of the position of the axis of rotation of Mars, made by Mr. Lowell. The direct method was employed, the position angle of the tangent to the limb at the nearest point to the polar cap being measured with a micrometer. The varying inclination of this tangent to the horizontal renders necessary the tilting of the observer's eyes in some positions; presuming that this might affect the resulting measures, Mr. Lowell has differentiated the results accordingly, calling them "expurgated" or "unexpurgated" as the time of observation was less or more than three hours after the horizontal position of the tangent.

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This was found to make less difference to the final result than that caused by observing the different oppositions.

The results obtained for the position of the pole of Mars are as follows:—

	R.A.	Dec.
Position upon the earth's equator...	315° 32′	54° 51′
Intersection of the Martian equator and Martian ecliptic	85° 56′	24° 32′
Inclination of Martian equator to Martian ecliptic	—	22° 55′

THE STRUCTURE OF METALS.[1]

THE subject of the lecture was the structure of metals, mainly as revealed by the microscope. The first serious application of the microscope to the study of metallic structure was made in 1864 by Dr. H. Sorby, of Sheffield, but the lead then given was not followed for nearly a quarter of a century. In the last fifteen years or so, however, it had been taken up with the greatest zeal and success, nowhere more than in Dr. Sorby's own town. There and elsewhere, in France, Germany, and America, as well as at home, a band of enthusiastic workers had been engaged in creating what might be described as a novel branch of physical science, as interesting on the physical side as it was important in its practical aspect. In this work Cambridge had done its share. The lecturer referred especially to work done in the engineering laboratory by Rosenhain, Humfrey, and other of his own former research students, and to the admirable investigation of alloys carried out by Neville and Heycock in the laboratory of Sidney Sussex College.

It was only possible to give in a single lecture a very brief account of part of this work. Photography had lent its powerful aid in recording what the microscope made visible. By means of lantern slides showing microphotographs of polished and etched metallic surfaces, the lecturer proceeded to exhibit the characteristic structure of a pure or nearly pure metal, where the whole mass is made up of irregular grains with well marked boundaries more or less polygonal in form. The grains could be distinguished from one another not only by the presence of the boundaries, but by differences of texture which were especially conspicuous under oblique lighting. Each grain was a true crystal made up of similarly oriented particles in a perfectly regular tactical arrangement, such as might be exemplified by imagining it to be built up of minute brickbats all of the same form and size. When a polished surface was etched the facets of the elementary brickbats were exposed, and the manner in which these reflected the light into or away from the microscope determined the appearance which the grain presented under oblique illumination. A slight change in the direction of the incident light would greatly affect the brightness of the grain, making it shine out or grow dull, but over each grain there was a uniform degree of brightness due to the uniformity of its tactical formation. Each grain had grown as a crystal, starting from a chance nucleus, and the boundaries were determined by the casual interference of grain with grain in the process of growth. In general, the growth was at first dendritic, skeleton forms shooting out until they met similar growths in neighbouring grains, and the interstices of the skeleton were filled in later. In some metals the grains were products of crystallisation from the liquid state; in others, notably in iron, a re-crystallisation took place long after the metal had solidified, and in such cases the grains, as we knew them under ordinary conditions of temperature, were the result of an internal re-arrangement which took place while the metal was solid. In such cases they were characterised by less regular boundaries, and there was evidence of more intimate interlocking between grain and grain. The structure might be fine or gross; in specially pure metals, and under specially slow conditions of cooling, it was apt to become specially gross. An instance was exhibited of a piece of lead of exceptional purity allowed to solidify by very slow cooling, in which the grains were so large as to be visible to the audience without magnification. Their appearance under oblique lighting was projected on the screen, and by tilting the block of lead the striking changes of brightness due to change in the incidence of the light were exhibited. Other evidences of the crystalline character of the grains were referred to, namely, the pits and geometrical forms developed on the surface by etching, and the geometrical forms assumed by very minute bubbles of gas or air imprisoned in the process of solidification.

Coming next to the consideration of effects of stress, the lecturer described the experiments by which, in conjunction with Mr. Rosenhain, he had demonstrated that the plastic yielding of metals when severely strained is due to a multitude of slips occurring along cleavage planes in the several grains of which the metal is a conglomerate. The appearance of "slip-lines" in various metals was shown, and the character of the lines was discussed. As Rosenhain had recently pointed out, the slip-lines were comparatively straight in grains formed by solidification from the solid (as, for example, in cast lead, silver, and gold), but were broken up into steps which gave them the appearance of being curved in metal which had undergone re-crystallisation while in the solid state. This was ascribed to the more intimate interlocking of the grains in the latter case. That the slips showed themselves by steps or sudden slight changes in the level of the surface was clearly demonstrated when the slip-lines were examined under oblique light. All the parallel slips on a given grain would then flash out simultaneously when the direction of the incident light suited the particular slope of the planes in which the slips had taken place. The form of slips in twin structures was exhibited, and also in an example (due to Humfrey) of lead with a structure so gross that the relation of the slips to the geometry of the grain could be readily traced.

A question of immense practical interest was the "fatigue" which metals underwent when exposed to many repetitions of a straining action. The microscope threw valuable light on this by showing how, under repetition of pulls or pushes or bendings, a piece began to give way, first by slips appearing on isolated grains, and then by some of these slips gradually developing into cracks. Instances were cited from a joint research by the lecturer and Mr. Humfrey. Mr. Rogers, who had pursued this subject with much zeal, had recently found that breakdown by fatigue was much more liable to occur in steel which had been thermally treated in such a manner as to develop a comparatively large structure than in the same steel when the treatment was such as to make the structure normally small.

Going on to speak of alloys, the lecturer described shortly the various ways in which two constituents might combine, or rather act together, in the composition of a binary alloy. In the liquid state each dissolved in the other, in the solid state one might remain wholly or in part dissolved in the other, forming what was called a solid solution. Thus with two constituents A and B, if A were present in small quantity only it might be found wholly contained as a solid solution in B. More generally, however, a solid solution would crystallise out first, leaving a mother liquor richer in A, which, by throwing down more and more solid solution, finally reached the proportion of the "eutectic" alloy, and then solidified as a eutectic mixture, showing under the microscope the zebra-like marking which characterised eutectic alloys. This process was explained by means of freezing-point curves, and was exemplified by a beautiful series of photographs taken by Mr. Stead, showing alloys of various proportional composition in which iron and phosphide of iron were the two constituents. When very little phosphorus was present, the whole solidified as a solid solution showing grains undistinguishable in general appearance from those of a pure metal. With a little more phosphorus the solid still consisted mainly of large grains, but the interstices (or in one case the inner parts of a dendritic skeleton) showed traces of the eutectic, which was the last part to solidify. With more phosphorus still the solid solution showed itself as incomplete skeleton grains interspersed with large quantities of eutectic. With more still the eutectic proportion was reached, and the whole solidified as a eutectic mixture, showing zebra markings all over the surface. With more still—that is to say, with an excess of phosphide—crystals of phosphide were first

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[1] Abstract of the Rede lecture delivered before the University of Cambridge, June 11. By J. A. Ewing, LL.D., F.R.S., Hon. Fellow of King's College, Director of Naval Education.

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